Low cost electrical current sensors with automatic measurement range

N.Galioto*, F. Lo Bue*, L. Mistretta*, C.G.Giaconia *
*University of Palermo - DEIM - Via delle scienze ed. 9, Palermo - Italy

We present a simple and low cost Smart Current Sensor with wide automatic measurement range. The logic core system of the sensor is tcondhe Atmel AT32UC3C2256C AVR 32-bit microcontroller[1], the wireless core is a Microchip MRF24J40MA IEEE 802.15.4 RF transceiver[3]. The MCU features 11 ADC multiplexed channels, with 12-bit resolution and sample rate up to 2Msps, two of which can be sampled in parallel. The sensing board consists of two hall-effect based current sensors[2], assembled on different PCBs in order to perform with different sensitivities. Custom primary conductor design (see figure 1) allowed us to sense the current flowing in the conductor with two different sensitivities: the sensor mounted inside the two PCBs gets a strong contribution from the traces on both the PCBs, the sensor mounted outside only gets a strong contribution from the traces on the bottom PCB.
In order to gather information about the sensitivity of each sensor, we run the system with some known flowing current configurations, and annotated the output voltage of each sensor. Table 1 shows the obtained sensitivities at each flowing current configuration. Currents higher than 7A saturate the output of the sensor with higher sensitivity, hence the constant reading of 4000mV and the consequently missing sensitivities. For each sensor, all the reported sensitivities were averaged, in order to linearize the output response and to build an approximated linear model of the system. The obtained values, 61mV/A for the sensor with one contribution only, and 204mV/A for the sensor with two contributions, were used to code the linear model inside the MCU firmware. Figure 2 shows that the linearized model fits the acquired data with good approximation.
The output voltage of the two sensors is acquired at the same time and with a 12-bit resolution. The auto-range selection, then, is simply done by analyzing the values of the sampled signals. In particular, for each pair of sampled values (V1, V2) we take the value V2 coming from the sensor with higher sensitivity, and compare it with a specific threshold. If this value is greater/lower than +/-1.9V, we replace it with the value coming from the other sensor V1.
Once the logic has chosen the “best” value V, we convert it to a known-scale floating-point number and perform the usual steps to compute the RMS value of the signal.

I_{RMS} (A)	$V1_{pk-pk}$ (mV)	$V2_{pk-pk}$ (mV)	S1 (mV/A)	S2 (mV/A)
1.65	300	960	64	206
2.19	410	1330	67	215
3.39	580	1920	60	200
3.88	700	2260	64	206
5.10	830	2860	58	199
5.18	860	2900	58	198
5.60	930	3220	58	204
7.18	1210	4000	59	
8.88	1450	4000	58	
8.96	1480	4000	57	
9.00	1520	4000	60	

Table 1: Sensitivity of the LEM sensors

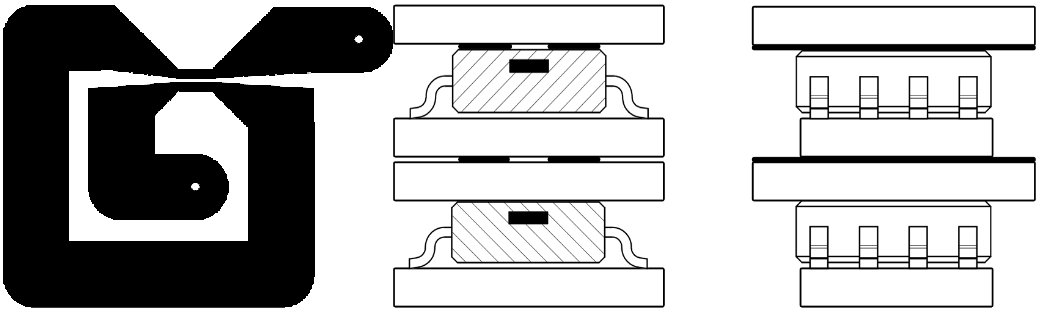

Figure 1. PCB trace design and assembled sensors. Top sensor is placed inside two mirrored PCBs and gets two strong contributions from the traces of both the PCBs. Bottom sensor gets only the strong contribution of the traces of the bottom PCB.

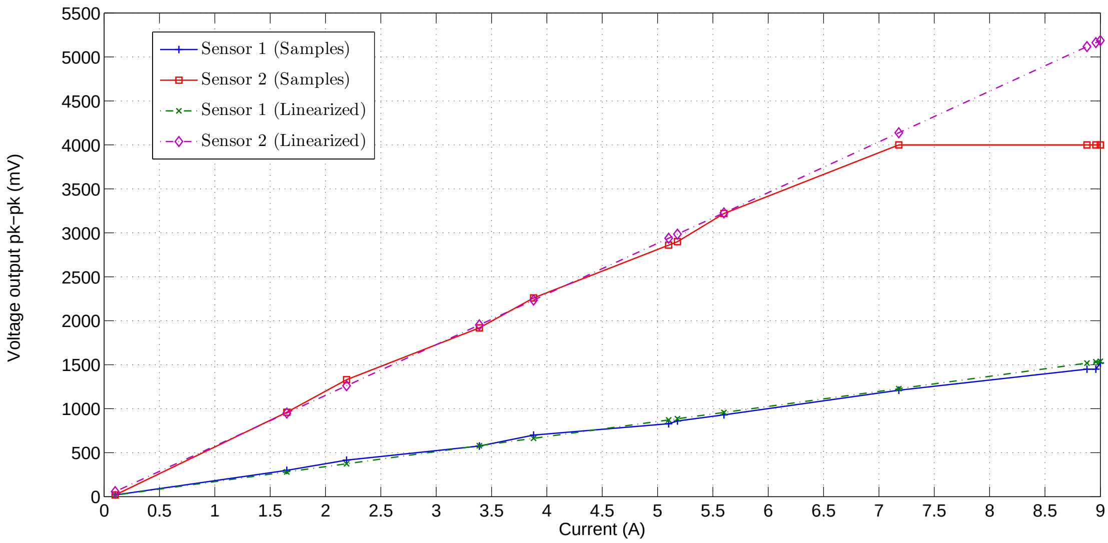

Figure 2. Output voltage of the sensors. The linearized model fits the acquired data with good approximation.

References

[1] Atmel AT32UC3C2256C datasheet http://www.atmel.com

[2] LEM FHS-40P/SP600 datasheet http://www.lem.com/

[3] Microchip MRF24J40MA 2.4 GHz IEEE Std. 802.15.4 RF Transceiver Module datasheet http://www.microchip.com/